Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/595
NORWAY
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

WATER CHEMISTRY RESEARCH AT HBWR

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The effects of various parameters on the net rate of water decomposition in a boiling heavy water reactor were investigated in the HBWR mainly to establish the feasibility of controlling the water chemistry by addition of deuterium and ammonia to the feed water. A further objective was to study the behaviour of the isotope N^{16} in a boiling system. The experiments were carried out at power levels in the range 5 - 18 MW and at pressures from 10 to 28 ata.

Under the conditions investigated, the net rate of water decomposition, which was of the order of 5 - 10 ml O_2 (STP) per kg of steam, i.e. smaller than reported for boiling light water reactors, was attributed mainly to radiolytic processes occuring in the boiling channels. Radiolytic equilibrium was attained in the moderator at rather low concentrations of radiolytic gas (about 0.05 ml O_2 per kg D_2O or less) and stripping of this gas from the moderator on passage through the fuel channels by natural circulation gave a relatively small contribution to the net rate of water decomposition.

An appreciable influence of parameters affecting the gas stripping efficiency in the fuel channels was observed, indicating a significant recombination of oxygen and deuterium formed in primary radiolytic processes. Thus an increase of the specific net rate of water decomposition (formation of radiolytic gas per kg of condensed steam) was observed

*) Paper prepared and presented on behalf of the OECD Halden Reactor Project - a joint undertaking of the European Nuclear Energy Agency.

with increasing steam production (exit steam quality up to 4%), increasing boiling density (i.e. increasing reactor power at constant steam production) and decreasing pressure (28 to 10 ata).

In accordance with the observation that, already without any additions to the feed water, radiolytic recombination occurs to an appreciable extent in the fuel channels, a marked reduction of the net rate of radiolysis was obtained with addition of deuterium to the feed water, e.g. from ca. 6 to ca. 0.03 ml O_2 per kg of steam at 10 MW and 28.5 ata. Similar to the observations with no addition to the feed water, the effect of deuterium addition showed a marked dependence on the stripping conditions in the fuel channels.

By adding deuterium to give about 0.3 - 0.4 ml D_2 per kg of moderator, the decomposition of ammonia added to the moderator into nitrous and nitric acids is prevented. The radiation stability of the ammonia with respect to decomposition into nitrogen and hydrogen was furthermore found to increase with increasing deuterium concentration in the moderator, in agreement with earlier results obtained at room temperature by one of the authors.

Due to the particular design of the primary system, the total concentration of gases which can be maintained in the moderator of the HBWR is rather limited (ca. 5 ml/kg). Because of this limitation, the possibility of producing ammonia in any appreciable concentration in the moderator (e.g.> 0.1 ppm) by radiation induced fixation of added nitrogen and deuterium was not feasible.